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birds. The latter gave attention indeed, but would not heed the repeated warnings. My advances had the effect of bringing all the flock together, whereas otherwise they would have scattered over the entire ledge of, say, a hundred feet length. Now and again the flock shifted, but always they came back, alighting at the extreme tip of the reef where the waves frequently bandied them. For the most part they fed silently, but as often as I made some unusual demonstration or as often as the wave swept about them, a murmur of complaint arose. The flock came to attention, or a few shifted position, if the water was actually too deep. But the moment danger was over, work was resumed upon the barnacles.

My last exposure, the last of twenty-one plates, was made at a distance of eighteen feet, and at that range only half of the flock would go on the plate. The exposure (f. 16, 1-140) was perfectly timed, and it marked, I am proud to confess, the most thrilling moment of a ten-year experience in bird photography.

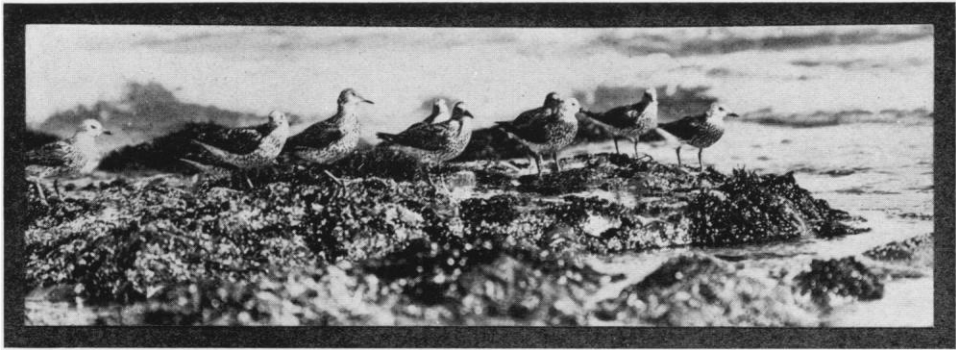


Fig. 6. SURF-BIRDS: THE PARTING SHOT
From a photograph, copyright, 1913, by W. L. Dawson

CONCEALING AND REVEALING COLORATION OF ANIMALS*

By JUNIUS HENDERSON

CONCEALMENT is only one factor of safety and not always the most important factor. There are numerous others, such as the sharp hearing, keen scent and speed of deer and antelopes, the weapons and strength of elephants and tigers, the protective armor of turtles and armadillos, the shells of clams and oysters, the spines of sea urchins and porcupines, the offensive or irritative secretions or stench of certain invertebrates, which render concealment comparatively unimportant in many cases.

Natural selection means the survival, not of those forms which have a single advantageous character, but of those whose combined characters as a whole best fit them for existence in their natural environment, surrounded by their natural enemies. Hence the very popular supposition that under the doctrine of natural selection all animals must be concealingly colored, is unwarranted in theory and unsupported by the facts. If a given species be varying in the direction of concealing coloration and in no other direction, naturally those forms, or mutants, or whatever we wish to call them, whose colors are in closest harmony, would be

* Abstract of an address before the University of Colorado Scientific Society.

likely to survive, and the others to perish. Another species may be varying in the direction of revealing coloration, but at the same time developing some other element of safety which far outweighs the disadvantage of revealing coloration, and thus would survive. Most naturalists who have studied the two in the field will probably agree that the crow, whose color under most circumstances cannot be considered at all concealing, is, because of its intelligence, alertness and activity, quite as capable of escaping its natural enemies, armed only with natural weapons, as is the ptarmigan, which affords one of the best examples of concealing coloration.

The law of compensation runs all through nature, animate as well as inanimate, and cannot be ignored by naturalists. In the natural course of things, a more or less revealingly colored animal would be expected to develop its alertness, speed or some other factor of safety, to a greater extent than its better-concealed neighbor. In fact, this seems to be the actual result in certain familiar cases, though not at all in other instances, so far as we may judge. There is some reason for the supposition that reliance upon concealment in many cases enables an enemy to approach very closely before escape is attempted. Thus concealing coloration, reacting upon mental and physical activity, may possibly sometimes be an actual disadvantage, if its concealing effect be known to its possessor, of which we cannot very well be certain until we can persuade the animals to tell us.

It is possible, if not probable, that many other causes besides the need of concealment contribute to the coloration of animals. Mr. Beebe's experiments upon the direct effect of moisture, dryness, heat, cold, diet, etc., upon animal colors are well known and enlightening, whatever the final conclusions may be. Some other facts bearing upon this phase of the problem, generally known to professional zoologists, are often ignored, and may not be so well known to amateurs. For example: (a) The general possession of dark skins by tropical animals, which is not confined to tropical human beings and which is possibly not due merely to the direct blackening of the skin by the sun ("tanning"), but to pigmentation for protection of the living tissues from the destructive action of intense light, excessive heat, or both. (b) The difference between different colors in their power to radiate heat, which may require animals of different habitat to be differently colored without reference to concealment. Thus such colors would be protective, yet not concealing. "Protection" is a broader term than "concealment," and the two should not be used synonymously. (c) The difficulties found in attempting to introduce white-skinned animals (swine) into certain regions, which may be due to the deleterious effect of intense light. (d) The difference in the color of domestic horses under different climatic conditions, possibly due to temperature or light, or moisture, a matter now under investigation. Professor Chas. F. Woodruff has recently discussed this subject (*Science*, n. s., xxxv, April 12, 1912, pp. 591-593). The recent change of color of the linnet introduced into Hawaii may be due to some such cause.

If no animal were in need of concealment, it is probable that species would still differ in color and color pattern. Among the smaller animals many species differ minutely in color and color pattern, yet so slightly that the differences are scarcely discernible, except by direct comparison, with specimens in hand. These differences can hardly be for concealment. Sometimes colors are the result of refraction of light due to physical structure, as in pearls, opals and iridescent feathers of birds. Sometimes they are the result of chemical composition, as in rubies, emeralds, sandstones, limestones, etc. In the cases just mentioned, except

perhaps feathers, the colors serve no known useful purpose, so far as the inanimate possessor is concerned. Many vegetable colors are surely not for concealment, though some may be for protection from light or temperature, and in case of flowers, possibly for the purpose of attracting insects, which would mean revealing, not concealing, coloration. Many leaves are countershaded, but not for concealment, surely. Internal organs, muscles and tendons of animals differ in color, but certainly not for concealment from enemies. Are not the beautiful yellow and black abdominal colors of the ring-necked snakes (*Diadophis, spp.*), under almost all circumstances, concealed, not concealing? Many heavy shelled mollusks which lie buried in mud and have practically no enemies except parasites and boring mollusks, and certainly have no need of concealment, are strongly lined with different colors. The species differ in color, surely not for concealment, as in many cases the colors are most emphatically not concealing when the animal lies on the beach sands unburied. Compare also the inside of the pearly fresh-water mussels, some species with chocolate-colored nacre, some rose-colored and some pure white, surely none for concealment. Innumerable other examples will occur to naturalists.

If no animal were in need of concealment, if coloration were purely haphazard, it is possible or even likely that the majority of them would be in a large measure concealingly colored. There are more neutral or dull colors, than bright and conspicuous colors. While bright colors do not always mean conspicuousness, yet a very brightly colored animal is quite apt to be conspicuous under a great many circumstances, while a dull-colored one is quite apt to escape observation in almost any habitat, if it remains quiet.

In the varying colors, lights, shades, and details of form of a forest, a small animal of almost any color or color pattern easily escapes observation while quiet, not because it is concealingly colored, but because it is only one in the great mass of detail, and the eye sees but a few out of the thousands of details. A black crow, a white heron and a scarlet ibis, all fairly large birds, standing side by side, could escape observation under many circumstances. Furthermore, in forest and brush patches, animals are almost always partly concealed or their outlines broken up by intervening twigs, leaves, etc. Even then it is noticeable that many birds which are good examples of concealing coloration take the precaution to keep a tree or bush between them and their enemies, a fact probably familiar to every ornithologist.

It has been argued that if concealing coloration is quite general, then we are warranted in assuming that it is universal, and that the apparent exceptions are exceptions simply because we do not know all the facts. That argument is quite unsound, and the acceptance of the doctrine of evolution, recently offered as an illustration supporting the argument, is not only not strictly parallel, but not in any way or in the slightest degree parallel. Naturalists will generally agree that the American bison and muskox in their native haunts are not concealingly colored and have no need for concealment from natural enemies armed only with nature's weapons. They are vegetarians and well able to protect themselves, except as against the artificial weapons of the human race, especially the death-dealing rifles of modern civilization. The same is true of many other animals. If this be admitted, then it follows that even though three-fourths of all animals are to an astonishing degree concealingly colored, the remaining fourth might be revealingly colored, because fully able to take care of themselves and perpetuate their kind, because of greater fecundity, intelligence, activity, strength, or other protective character or device.

That there are almost innumerable cases of concealing coloration, in varying degrees of perfection, is so generally conceded that it needs no argument or citation of instances; and some species are so colored as to easily escape observation in such a great variety of situations as to make quite unnecessary the Messrs. Thayers' elaborate, interesting, and in the main perhaps correct, explanation of how different types of broken patterns are suited to different types of background. Difference of opinion is found only when we come to discuss certain definite species or to decide how nearly universal the phenomenon is.

That there are many cases of clearly revealing coloration (such as the bison above mentioned) is usually admitted, even by the most radical advocates of the other side of the problem, though often in their generalizations they use language which plainly contradicts their admissions of exceptions. Among animals which would apparently be as much benefitted by concealment as others, there are such numerous unexplained inconsistencies as may well cause one to hesitate about wholesale declarations. Many of the explanations offered utterly fail to explain. One must wonder if the assertion that white herons are concealingly colored because they are seen by their prey or their enemies against a white sky is at all satisfactory to anyone familiar with the range, habits and habitats of this and other herons. Is it not more often seen in solid white, outlined against a deep blue, leaden or gray sky, or a dark bank, or a solid bank of foliage? At any rate, before the white heron was exterminated over most of its former range, it was found, at least in many places, in the same habitat, and, so far as one may judge, with practically the same feeding habits, as the blue and green herons. Such instances as this, and they are quite numerous, should not be lightly passed over. It does not help matters to say that if we knew more of the intimate life relations of these animals we would find all to be concealingly colored, because that is a mere assertion.

Another large class of inconsistencies involves those species of which the male is radically different in color from the female. Forced explanations are not conducive to scientific progress. Taking the redwing as a much discussed example, it has been asserted that the male is concealingly colored because it is seen by its enemy, the hawk, from above, against the dark mud and dark foliage of its swampy habitat, and that the lighter wing-patch would be easily mistaken for a flower. Yet over a large part of its range (including, of course, the various slightly differentiated species and subspecies) during a large part of the year it finds no dark mud or dark foliage as a background. Species should be considered in relation to their whole range and to all other species and other elements of their environment. Even more difficult are those species of which the male is much like the female during part of the year, but wears more conspicuous colors during the nesting season. The theory that the conspicuous color is assumed in order that the male may attract the female is hardly satisfactory. The theory that the male is so colored in order to attract enemies from the nest may possibly have some weight, especially in view of the habit developed by other species of leading enemies from the nest by fluttering along the ground as if wounded. Such species as the bobolink and lark bunting, the males of which, more conspicuously colored, rise into the air and then sing as they glide downward as if purposely to attract attention to their alighting-place, afford a chance for observations of value on this point, if they have not been made, by noting in a great number of cases whether the bird glides down toward the nest or away from the nest. An objection to this theory is that many of the conspicuously colored males assist in feeding the young when hatched, and some, at least, habitually feed the female

on the nest. If the purpose of the difference between male and female is to lead enemies from the nest it would be a protective device, but certainly not a case of concealing coloration, so far as the male is concerned. The doctrines of warning colors, and mimicry, besides the lack of convincing evidence of their validity, appear to admit that all color patterns are not concealing.

Another set of inconsistencies includes the croaks of frogs, the songs of birds and the cries of mammals. Why should nature provide concealing colors for a pika, a woodchuck, or a prairie-dog, and then endow it with an instinct which induces it to attract the attention of every enemy which approaches? Everyone who has studied nature in the field must know that a large percentage of birds and mammals which are observed, either by man or by lower animals, would escape observation, if, to use the vernacular, they "had sense enough to keep their mouths shut" and remain motionless. These cries, croaks and songs are not for the purpose of leading enemies away from nests or young, because they are not confined to one sex or to the breeding season.

To take care of the seeming exceptions to the concealing coloration doctrine it has been boldly asserted that "all patterns and colors, upon all animals whatsoever, except such as live in the dark, or are neither predatory nor preyed upon, are, when seen against the background against which their enemy (or prey) would see them at the critical moment, inexpressibly perfect pictures of the background, and therefore obliteratively colored." The circumstances of the critical moments of most species vary so enormously, and such moments occur in varying circumstances so often with some species, that it is difficult to conceive how anyone at all familiar with nature could indulge in such a statement. It is quite on a level with another assertion of the same author, that "one may read on an animal's coat the main facts of his habits and habitat, without ever seeing him in his home." As the crow's color does not change, does it display "a perfect picture of the background" when the critical moment occurs in a cornfield, or in a cottonwood tree, or on the rock crags of the Rabbit Ears, or when the ground is bare, or when it is white with snow? If it be suggested that it is when on the nest, the obvious answer is that the nesting sites vary greatly, and surely that suggestion could not apply to the same query concerning the male of the redwing, or any species whose male takes no part in nest building or brooding. A moment's thought must flood the mind of every zoologist with specific objections to the assertions above quoted.

The critical moment theory has been particularly applied to those animals which have white rump patches or white tails, or both. I have been familiar with the prong-horn antelope since 1883 and with the rabbits for a much longer period, and have never seen either dog or coyote puzzled for a second by the fact that the posterior white parts were thrown against a sky and so obliterated. During the past two seasons I have had more opportunities to watch dogs pursue cottontails and jackrabbits than ever before, and they followed unerringly, often at close range, up hill where the rabbits were almost constantly against the sky. In case of the antelope, it is, so far as my observation goes, usually the flashing of the white patch that attracts the attention of its enemy, whether man or beast. It is inconceivable that nature has provided it with such a distinctive advertising character, to attract the attention of all the coyotes in the vicinity, merely in order that it might sometimes be seen against a white sky and thus throw the enemy off the trail, even if we can presume that the animal's enemies pursue their prey entirely by sight. My own observation is that most of our forest rabbits are not seen usually against a sky background, or even a forest background with

patches of sky showing through, but much more often against a solid dark background of canyon wall, river bank or solid green foliage. Of course this proves nothing, unless it coincides with the observations of others made with this particular question in mind. Even in a level, treeless region, during the past season, I could not see that the low bounds of a cottontail ever carried its rump high enough to bring it to the sky line, from the standpoint of a coyote, except for a fraction of a second at a time. Furthermore, the chief enemies of the rabbit, in many localities, are not mammals, but large birds of prey, which surely do not often see their quarry against white skies. This is also true of the white-tailed prairie-dogs of the intermountain region of Colorado. Whatever their purpose, that such white posterior markings are obliterative from the standpoint of the possessor's enemies is altogether too doubtful to be accepted without thorough testing on many species. Mr. Thayer's photographs do not show the animals in the position in which they would usually be seen by their enemies at the "critical moment," in my judgment.

Thayer's theory of countershading seems correct as an optical principle, but needs to be studied from many angles before acceptance as a part of the concealing coloration theory. Many animals which are rendered quite indistinct in the middle of the day, when the light comes from above, are not so indistinct earlier and later in the day. Thayer himself admits this, apparently, in the case of the jacanas. I have found it true with the cottontails of the western plains during the past summer. As many countershaded animals are in hiding during the hours when the countershading would be most effective for concealment, and moving about when it is least effective and in some instances even disadvantageous, it is well to look for some other explanation of the phenomenon and not to hastily assume that its purpose is concealment.

Thayer's ruptive design theory is possibly one of the most important ones he has advanced. In certain environments, at any rate, the breaking up of the outlines of animals in the way suggested is a most effective method of obliteration.

Nearly all the discussion of concealing coloration has assumed that all animals have the same powers of vision as man, see things just as man does, and at least one prominent author has expressly declared this to be true. Nothing could be farther from the probability. All men, even, have not equal visual powers. Aside from individual color blindness, there is strong evidence indicating that it is a racial character of some primitive peoples (*Science*, n. s., xxii, 1905, p. 680), thus reviving the old theory that in the development of color perception the colors at the long-wave end of the spectrum were first perceived, and that only a few animals have yet reached the higher colors. Birds probably have color vision, though very little is yet known of its extent or universality. Experiments under proper control up to the present time indicate that many of the mammals have not color vision, but only the power of distinguishing between brightness and dullness. Such experiments, to be of any value whatever, are very difficult. There are reasons for the belief that amphibians and reptiles have only motion vision, which, if true, would nullify the numerous statements about such animals being unable to see their enemies on account of concealing coloration. It is quite certain that all animals are more apt to see any object in motion than a motionless one. It is also doubtful whether any animal except the primates has binocular vision, a matter of very great importance. It is generally believed to represent the difference between an ordinary flat photograph and a stereoscopic view, which brings the scene out into sharp relief. Anyhow, binocular vision is one of the important factors in the perception of solidity, rotundity, etc. Whether the

lower animals have developed some other faculties as substitutes for color vision and binocular vision is not yet determined. Experimentation, properly controlled, along these lines, is difficult, but if the matter of concealing coloration is ever to be settled, naturalists must begin to pay more attention to the work of the experimental psychologists, testing the results of their experiments, wherever possible, by field observations. Until there is some reason for thinking that coloration is necessary for the concealment of animals from their enemies, or that coloration would be effectual for that purpose, the doctrine, in view of all the apparent exceptions and inconsistencies, stands on rather insecure ground. There is no reason for assuming that animals in their natural habitat appear to other animals as they appear to man.

Finally, the camera does not represent animals in their habitat as they appear to man, both on account of the lack of color and relief, and great reduction of scale in order to show habitat. Stereoscopic views would correct the latter, if it were economically practical to publish them, but color photography has not yet developed far enough for general use in the field. It is fairly safe to say that no photograph has yet been published which exhibited the animal as clearly as it was visible to the human eye. Some authors have frankly acknowledged this in discussing concealing coloration, but others have said the opposite. Especially reprehensible is the indulgence in taking photographs out of focus in order to obscure outlines and patterns, ignoring scale and perspective in paintings and drawings, and placing objects in front of one figure to obscure it in order to show that it is concealingly colored, and omitting the objects from before another figure to show that it is not, all of which have been practiced in advocacy of the concealing coloration doctrine.

SWALLOWS AND BED-BUGS

By EDWARD R. WARREN

IN MY paper in the May-June CONDOR, 1912, entitled "Some North-central Colorado Bird Notes," I referred to the belief that swallows harbor bed-bugs as ridiculous; and now I have to confess that possibly I did not know as much as I thought I did, a not uncommon failing with us all. Some time after the paper was published, W. Leon Dawson in a very courteous letter, called my attention to the fact that he had found Cliff Swallows' nests badly infested with bed-bugs, in one case so much so that the colony had been deserted. He reported this in "The Birds of Washington," page 333. This started me to looking into the matter, something I had not done before, and as it would seem that not very many are posted on the subject, and in fact but little definite has been published that I have been able to find, I have thought it worth while to write up what little I have been able to learn about the matter, together with a few observations of my own, in the hope that it may be the means of bringing out further information. Certainly ornithologists should do their part in ascertaining whether or not swallows are guilty of bringing such disagreeable pests into human habitations.

I found that a bug (*Acanthia hirundinis*), belonging to the same genus as the true bed-bug (*Acanthia lectularia*), is parasitic on swallows, pigeons, chickens, and bats. It should perhaps be stated that the French authority, L. Gedoelst, places it in another genus because of certain structural differences,